AD/RHIC/RD–17

RHIC PROJECT

Brookhaven National Laboratory

Gradient Errors & Correction System Summary

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b_1 Errors

Effects:

- Tune shift horizontal & vertical
- Half integer stopbands $\sim \Sigma\beta b_1 \ell e^{i2\psi}$
- $\Delta\beta/\beta$ for on–momentum particles $\sim \Sigma\beta b_1 \ell e^{i2\psi}$
- Horizontal dispersion $\sim \Sigma\sqrt{\beta_H}\, X_p b_1 \ell e^{i\psi}$
- Uncorrectable closed orbit error for off–momentum particles
- Reduced acceptance
- Reduced luminosity if β^*, X_p^* increased
- Increased beam–beam effect (??)

Source of errors:

b_1 in dipoles

Δb_1 i.e. mostly length errors in quadrupoles (insertions dominant)

Feed down for sextupoles if closed orbit off

No installation errors!

Correction:

- Sorting of arc dipoles + QF/QD reduces $\Delta\beta/\beta$ & stopband
  (No b_1 random correctors in arc required.)
- Closed orbit error control (eliminates sextupole feed down)
- Trim power supply at each insertion Q eliminates insertion errors
  Correct β^*& X_p^* at X–ing point
- Correction of horizontal dispersion by using b_1 at QF in arc (2 families/arc)
  (same lead arrangement as for transition jump however power supply conflict?
  CDR wiring has to be changed.)

— Correct *residual* $\Delta\beta/\beta$ & stopband

Parzen $\longrightarrow$ Insertion Quads

Ruggiero $\longrightarrow$ Need b_1 at QF (different lead configuration from transition jump)

Need b_1 at QD (Incompatible with a_1)

Compromise $\longrightarrow$ Bypass on QF & QD in arcs

(This solution is in effect a stop band correction system in the arc. It is separate from the gamma transition system and leaves space for the a_1 correctors.)

a_1 — Errors

Effects:

— Stop bands

Difference resonance (coupling) $\nu_x = \nu_y$

Sum resonance 57, 58th harmonic

— Coupling (ν_x, $\nu_y \rightarrow \nu_1$, ν_2 / β_x, $\beta_y \rightarrow \beta_1$, β_2)

Driven by average (systematic) a_1

— Betatron function distortion

resulting in loss of acceptance

Driven by sum resonances

— Tune splitting (ν_1 - $\nu_2 > 10 \times 10^{-3}$)

equivalent to lacking control over betatron tunes

— Vertical Dispersion

1) at X–ing points: loss in luminosity
2) at injection & beam dump

Sources:

— a_1 in dipoles

dominant contribution to systematic a_1

— Rotation of quads: INSTALLATION ERROR

$\beta^* = 6$ m Arc Quads $\approx$ Insert Quads contribution

$\beta^* = 2$ m Insertion quads dominate

— Vertical closed orbit errors in sextupoles (feed down)

Correction System

— Sorting of dipoles but improvement limited due to quadrupole installation error

— Vertical closed orbit error control (eliminate feed down)

— Coupling correction

1) Skew correctors at Q2/Q3 and Q5
2) Error correction at the source with a_1 at QD in arc
   Compensate systematic a_1 in each arc (this is dominant source of coupling)

— Betatron distortion correction

Sum resonance stopband correction with a_1 at Q2/Q3 and Q5 individually adjusted

— Vertical dispersion correction

S.Y. Lee: a_1 at Q9

together with a_1 at Q2/Q3 and Q5

(This solution would provide space for b_1 stopband correctors at QD)

Parzen: a_1 at QD in arcs

(Wiring configuration simulates Q9 and allows simultaneous coupling correction)